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THE MANURIAL VALUE OF ASHES, "MUCKS," SEA WEEDS AND BONE.

This Bulletin contains the results of analyses of wood ashes, impure peats locally called "mucks," sea weeds and bone meal, together with practical suggestions as to the use and handling of these materials. Food analyses of common sea weeds eaten by sheep on the Maine coast are also given.

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AGRICULTURAL EXPERIMENT STATION,

Orono, Maine.

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THE MANURIAL VALUE OF ASHES, "MUCKS," SEA-WEEDS AND BONE.

CHAS. D. WOODS.

In his efforts to grow crops the intelligent farmer must ever try to conserve and add to the stock of available plant food in the soil. The fertility of a soil is measured by its power to produce crops. A soil may have many hundreds of pounds of plant food per acre, and still be unfertile, while another may contain little plant food, but may have that little in an available form and thus be productive, i. e., fertile.

Usually manures are applied to soils for the double purpose of supplying plant food in an available form and unlocking the unavailable compounds already in the soil. The direct manurial value of fertilizing materials of the *same class* can be accurately measured by chemical analysis. Sometimes as the results of field and pot experiments it is also possible to extend this comparison of analyses to materials of unlike nature. In general, however, it is not enough to know the pounds of nitrogen, phosphoric acid and potash in a given manure, but we must by actual experiment with the living plant find out how much of these materials is available to the plant. In studying the manurial value of the three classes of fertilizing materials discussed in this bulletin, these facts must be kept in mind. For example, in comparing a "muck" with 2½ pounds of nitrogen in 100 pounds of dry matter with stable manure with only 1¾ pounds of nitrogen in the same weight, a great mistake would be made in thinking the muck a better fertilizer than the manure. The nitrogen of the muck is largely unavailable as plant food until it has been treated by composting, exposure to the air, etc., while the stable manure contains in itself the ferments necessary to render its nitrogen available to the growing plant. In like manner the

phosphoric acid of a superphosphate is in a form ready to be assimilated by the growing plant, while that of wood ashes may be practically insoluble and only slowly available to the plant.

If plant food is not in an immediately available form the material containing it may still possess manurial value. To utilize all kinds of plant food at one's disposal is an important item in farm economy. The classes of such materials more or less accessible to the farmers of Maine are ashes, "mucks" seaweeds and bones. Partly because of accumulated unpublished analyses of samples sent to the Station by correspondents and partly in answer to inquiries respecting the manurial value of these materials, this bulletin has been prepared.

Wood Ashes.

Maine farmers are pretty well agreed as to the high value of wood ashes as a fertilizer. The fertilizing value of wood ashes is commonly attributed to the potash which they contain. While the potash has the largest money value of the fertilizing constituents of ashes, their agricultural value also depends upon the not inconsiderable amounts of phosphoric acid and the large amounts of lime which they carry. The importance of these last constituents is indicated by the high value some farmers put upon leached ashes as a manure, although in leaching nearly all of the water soluble potash has been removed. The potash content of ashes varies with the kind of wood, the method of burning, and the care taken of the ashes to protect them from rain.

The Ontario Agricultural College* has made quite a study of the composition of the ashes of different woods. And while these results, usually from single specimens, cannot be taken as final, they are suggestive and instructive. Some of the more important of these analyses are given in the table which follows.

*Report Ontario Agricultural College and Experimental Farms, 1896, pp.24-26.

POUNDS OF PHOSPHORIC ACID, POTASH AND LIME IN 100 POUNDS WATER-FREE ASH OF THE WOOD OF THE TREES INDICATED.

Kind of wood.	Phosphoric acid.	Potash.	Lime.
Sugar Maple	2.03	9.31	45.24
Soft Maple	1.29	9.52	41.97
Black Ash	1.20	25.30	49.04
Oak	1.69	9.39	43.54
Birch	1.47	8.58	37.10
Elm	.45	35.37	23.64
Beech	1.39	7.58	41.21
Apple	1.81	4.84	44.93
White-Ash	.93	16.88	37.14
Basswood	5.28	9.39	33.42
Poplar	2.98	10.42	28.38
Hemlock	2.76	8.73	45.83
Pine	4.03	11.22	20.28
Cedar	.98	3.30	49.06
Spruce	4.00	8.98	25.82

As stated above, the results of the analysis of single specimens of wood can be taken as indications only. In two instances this Station has analyzed the ash of known woods with results differing from the above as follows:

PHOSPHORIC ACID AND POTASH IN 100 POUNDS ASH OF BIRCH AND CEDAR. THE RESULTS OF MAINE ANALYSES COMPARED WITH THOSE OF CANADA.

	Phosphoric acid.	Potash
Birch, Maine analyses	6.05	12.04
Canada analyses	1.81	8.58
Cedar, Maine analyses	1.91	5.09
Canada analyses	.98	3.30

With allowance for individual variations the results are striking and interesting. The popular idea of the low value of beech ashes is confirmed but the prevailing belief in the low value of soft wood ashes as compared with hard wood ashes does not seem to be well founded. The potash in maple, oak, birch

and beech averages rather less than that of hemlock, pine and spruce. While this is true of the carefully prepared ashes, it does not seem to hold in the case of ashes actually made in burning. The following table shows the analyses of different samples of gathered ashes made by this Station:

POUNDS OF FERTILIZING CONSTITUENTS CONTAINED IN 100 POUNDS OF DIFFERENT SAMPLES OF WOOD ASHES ANALYZED AT THE MAINE STATION.

Laboratory number.	Kind of ashes.	Water.	Phosphoric acid.	Potash.			Lime.
				Soluble in water.	Insoluble in water.	Total.	
	Unleached Ashes.						
71	Hard wood	4.40	3.00	7.12	1.34	8.46	38.60
74	Mostly hard wood	.80	2.56	7.74	1.26	9.00	36.59
85	Pure birch wood	.06	6.05	10.43	1.61	12.04	39.07
82	Hard wood	3.30	2.98	5.24	2.06	7.27	31.65
250	Hard wood	.....	2.00	7.82	.....	.....	.....
3003	Hard wood, Canada	.....	.....	9.65	.....	.....	.....
3013	Hard wood, Canada	.....	.....	8.09	.....	.....	.....
	Hard wood, average	2.40	3.32	8.01	1.56	9.57	36.48
70	Soft wood, household fires	4.64	1.78	2.64	2.01	4.65	23.62
834	Cedar ashes	1.52	1.91	5.09	.....	.....	.....
	Dump ashes:						
64	Soft wood, mostly spruce	20.63	.64	2.38	.64	3.02	29.36
66	Soft wood, mostly spruce	3.84	1.50	1.35	1.27	2.62	31.22
67	Soft wood, mostly pine	.....	.66	.40	1.13	1.53	37.72
86	Mill waste, mostly spruce	.....	1.58	1.90	1.16	3.06	38.72
	Soft wood, dump, average	.....	1.09	1.51	1.05	2.56	34.25
	Mill furnace ashes:						
65	From spruce sawdust	1.19	1.40	3.43	.96	4.39	35.90
68	Soft wood, mostly spruce	.....	1.27	.88	1.05	1.93	46.14
69	Soft wood, mostly spruce	88	1.47	3.50	1.70	5.20	46.20
587	Soft wood, mostly spruce	...	2.70	4.69	.....	.....	.....
3004	Soft wood, mostly spruce	..	.....	2.56	.....	.....	.....
3014	Soft wood, mostly spruce	..	.....	5.70	.....	.....	.....
	Soft wood, furnace, average	.....	1.66	3.46	1.24	4.70	42.75
	Canada ashes—car lots:						
3024	.....	.....	.....	3.27	.....	.....	.....
3025	.....	.....	.....	5.68	.....	.....	.....
3026	.....	.....	.....	6.64	.....	.....	.....
3042	.....	.....	.....	4.54	.....	.....	.....
3043	.....	.....	.....	3.85	.....	.....	.....
3084	.....	.....	.....	5.71	.....	.....	.....
	Canada ashes, average	.....	.....	4.95	.....	.....	.....
76	Spent tan bark ashes	1.05	1.44	.98	1.12	2.10	.....
843	"Muck" ashes	.....	Trace	.....	.....	Trace	.....
	Leached Ashes.						
72	Hard wood	32.95	1.91	.46	.97	1.43	25.48
75	Mostly hard wood, mixed	31.25	1.54	.35	.93	1.28	20.00
77	Mostly hard wood, probably	31.22	1.52	.90	.56	1.46	32.97
80	Mostly hard wood	31.40	1.96	1.13	.72	1.85	29.06
73	Soft and hard wood, mixed	34.05	1.42	.29	1.32	1.61	20.54
81	Mostly hard wood, Canada	25.43	1.60	.94	.59	1.53	31.12
	Leached ashes, average	31.05	1.66	.68	.85	1.53	26.53

For the purpose of clearness the averages of the preceding table are given in a concise form in the table which follows:

POUNDS OF WATER, PHOSPHORIC ACID, WATER SOLUBLE POTASH AND LIME IN 100 POUNDS OF DIFFERENT CLASSES OF WOOD ASHES.

Kinds of ashes.	Water.	Phosphoric acid.	Potash soluble in water.	Lime.
Unleached hard wood		3.3	8.0	36.5
Unleached soft wood, household		1.8	2.6	23.6
Unleached soft wood, dump		1.1	1.5	34.3
Unleached soft wood, mill furnace		1.7	3.5	42.8
Unleached Canada, car lots			5.0	
Leached mixed wood	31.0	1.7	.7	26.5

The results of the analyses indicate very clearly that different samples of ashes differ markedly in their manurial value. The unleached hard wood ashes are of much greater value than those of soft wood. As seen from the table on p. 67 this cannot be attributed chiefly to the kind of wood, but more to the method of burning and subsequent care. Potash is volatile at a not very high temperature and in case of very hot fires much of the potash would be driven off and lost. Dump and furnace ashes are more or less exposed to the weather. The rains if copious enough to wet through the pile would leach the ashes and carry off more or less of the water soluble potash. In case of a dry pile partially wet, the water falling upon the top will dissolve out the potash in the upper layers and carry it to the lower part of the pile. In the case of damp ashes drying out, the movement of water is toward the top and the water containing the potash would be drawn to the top and evaporate, leaving at the top of the pile the potash in the form of a more or less crystalline crust. With the next rain this would be dissolved and carried down into the pile to again reappear at the surface in subsequent evaporation of the moisture. It therefore follows that the composition of a pile of wet ashes is not uniform and that portions of it

would be poorer than other parts in plant food. In selecting samples for analysis great care needs to be taken in order to be sure the sample fairly represents the whole.

The potash insoluble in water is chiefly the silicate of potash which is only slowly if at all available to plants. The phosphoric acid is all in insoluble form and how readily available is not known.

In addition to their manurial value, ashes have a decided effect upon the capillary power of the soils. If a solution of carbonate of potash, such as potash of wood ashes, is poured upon loam, it will be made muddier and stickier than it would be if moistened with water. Milton Whitney of the United States Department of Agriculture has investigated this subject and finds that alkaline solutions seem to loosen the particles of the clayey soil from the particles of sand and float off the clay particles, so as to fill up the spaces between the sand grains. As a result of this clogging of the pores, the circulation of the water is much retarded. That this action of an alkali is sometimes of great practical importance is attested by the fact observed by Whitney, that soils are met with in which the particles of clay are held so closely to the grains of sand that the soil has the appearance and properties of a sandy soil, although it may actually contain as much clay as many so-called clay soils. Carbonate of potash has a tendency to keep clay in a "puddled" condition. A ball or lump of moist clay, held together with alkaline carbonate does not tend to crumble during the process of drying, but remains a hard lump. As unleached ashes carry large amounts of potash lye, the application of ashes may have practically the same effect upon soils as the addition of carbonate of potash.

Potash soils also have a decided action upon soil nitrogen. These alkaline solutions have great power to dissolve organic matters and render unavailable nitrogen available. This tendency of potash to promote rank growth is well illustrated wherever the land has been recently cleared of wood and the logs burned. The rankness of growth which follows is probably due not only to the available potash thus returned to the soil, but also to the superabundant supply of nitrogenous food made available by the action of the alkali upon the soil humus and to the fact that alkali has a tendency to retain moisture.

A favorite way of applying wood ashes is as a top dressing to mowing or pasture lands. This encourages the growth of clover and some of the better grasses, with a tendency to crowd out inferior kinds of grasses, weeds and moss.

The presence of an alkali seems to favor the growth of potato scab. On land free from scab fungus, ashes are beneficial for potatoes. Leached ashes depend chiefly upon the phosphoric acid and lime for their value. Coal ashes have no fertilizing value and any effect they may have depends upon their mechanical condition.

A bushel of average unleached hard wood ashes weighs about 48 pounds. This would contain

Potash	about	4	pounds, worth	20	cents
Phosphoric acid	"	1½	" "	3	"
Lime	"	18	" "	7	"

Wet ashes are not much more compact than dry. A bushel of wet ashes weighs considerably more than a bushel of dry ashes, but this difference is chiefly due to the water. A bushel of wet or leached ashes contains about 50 pounds of dry matter or practically the same as a bushel of dry ashes.

Canada ashes as sold in car lots in this State carry from 3 to 7 per cent of potash, and would at the valuation thus used be worth from 18 cents to 28 cents a bushel. Average dump ashes at the same valuation will be worth about 13 cents, and average mill furnace ashes about 15 cents a bushel. In buying, the cost of carting and applying needs to be taken into account.

"Muck."

The correct use of the word muck, which means dung in a moist state, has been entirely lost in New England and is applied without much discrimination to any bog earth derived chiefly from decaying vegetable matter. The term as used includes materials ranging from a bog meadow mud to quite perfect peats. Large deep bogs containing true peat are comparatively few in New England, but small, shallow depressions, containing impure peats, occur everywhere. The gravelly soils of New

England need the addition of large amounts of organic matter and these impure peats have been thus used for generations under the general name of "muck." While the use of the word in this sense is provincial and perhaps not to be encouraged, it will be so used here for lack of a better term. By "peat" is generally understood a somewhat similar product in which the decomposition has not advanced so far. Such material is usually brownish in color and when dry has considerable fuel value.

These peaty soils or mucks are the results of the partial decay of vegetable materials. They are found in swampy places filled with stagnant water. The successive growth of sphagnum and other water-loving mosses, as well as the forest leaves falling into the water, are changed by decay into the black earths and impure peats. Mucks thus formed contain appreciable amounts of insoluble nitrogen and usually but little mineral matters, unless sand, clay or silt has been washed into them during their formation. Mucks owe their peculiar properties to this decomposed vegetable matter, which constitutes the *humus* of the agricultural chemist.

ANALYSIS OF MUCKS.

During the past few years the Station has examined for correspondents a number of samples of these materials from different parts of the State.

The following table shows the pounds of water contained in mucks as they are taken from the bogs, and the varying weights of ash, organic matter, nitrogen, phosphoric acid and potash contained in 100 pounds of the *water-free* (perfectly dry) mucks:

POUNDS OF WATER IN 100 POUNDS FRESH MUCKS AS TAKEN FROM THE BEDS AND THE POUNDS OF ASH, ORGANIC MATTER, NITROGEN, PHOSPHORIC ACID, AND POTASH IN 100 POUNDS OF PERFECTLY DRIED MUCKS.

Laboratory number.	Locality.	Water in fresh mucks.	In water-free material.		Phosphoric acid.	Potash.
			Organic matter.	Nitrogen.		
278	South Sebec	83.2	86.9	2.77	.17	.02
279	Turner	75.1	78.9	1.29	1.15	.07
280	Brunswick		96.2	1.98	.27	.17
281	New Gloucester		57.9	1.15	.26	.04
282	Freedom		65.4	1.51	1.97	.27
835	St. Albans	77.5	80.9	1.70	1.08	.14
841	Burkettville	80.7	92.3	2.16	.54	.08
842	Burkettville	79.5	65.6	1.67	.96	.20
218	Thomaston		57.2	2.06	.46	
219	Wayne		84.0	1.63	.13	
220	East Eddington		94.5	1.56	.11	
243	Charlotte	78.5	51.6	1.78	.28	.47
298	North Leeds	85.3		1.75		
3001				.68	.02	.06
3002	Readfield	86.8		1.86		
3065	Auburn			1.78		
3105	Richmond Corner	86.5		2.85	trace	trace
3106	Burnham			1.36	.22	.59
3107	Burnham			2.53	.34	.20
3165	Jackson			1.46	.44	.23
3166	Grange			1.19		.20
3167	Bar Harbor	80.7		1.26	trace	.90

POUNDS OF ASH, ORGANIC MATTER, NITROGEN, PHOSPHORIC ACID, AND POTASH IN 100 POUNDS OF DRY MATTER OF SUBSTANCES SOMEWHAT RESEMBLING MUCK IN APPEARANCE.

Laboratory number.	Kind of Material.	Ash.	Organic matter.	Nitrogen.	Phosphoric acid.	Potash.
221	Sea shore "muck"	22.7	77.3	.69	.16	.62
222	Decomposed sphagnum			.87		.12
241	Mussel mud			.32	.16	1.06
3167	Mussel mud			.46	.59	1.43
593	True peat	18.1	81.9	.34		
244	Drift on lake shore			2.07	.25	.19
395	Soil from dyked marsh			2.45	.24	.28

WATER IN MUCKS.

The large amount of water contained in this class of materials makes their handling laborious and expensive. When first shoveled out of the bed, more than three-fourths of the weight is due to the water. In the table it will be noted that the least water in 100 pounds of muck as taken from the bed was 75.1 pounds and in several cases there were more than 85 pounds of water in 100 pounds of the freshly shoveled muck.

It is never the case that mucks can be made perfectly dry in field or barn treatment. They are very retentive of moisture and even when shoveled out of the pit and allowed to remain in a heap until the dry season of the year, they still usually contain 40 to 50 per cent or more of water. If these materials are to be used as an absorbent in the stable, it is important that they be as thoroughly dried as practicable and kept protected from rains. One hundred pounds of well dried peaty muck will absorb 4 to 6 times its weight of urine.

ASH OR MINERAL MATTERS IN MUCKS.

The quantity of ash in these impure peats examined by the Station is variable but is usually large. In one instance only 5 per cent of the dry matter was ash, while in another sample 48

pounds out of 100 pounds of dry muck was ash. This ash is chiefly sand and has very little fertilizing value. On this account, therefore, the greater the amount of ash generally the poorer the muck. The quite complete analysis of the ash of five samples of muck follows. The laboratory numbers of the samples are the same as in the table on page 73.

POUNDS OF MINERAL MATTER IN 100 POUNDS WATER FREE MUCK.

	Sample number 278.	Sample number 279.	Sample number 280.	Sample number 281.	Sample number 282.
Sand, silica, etc	.37	17.17	2.20	35.53	23.74
Iron oxide and alumina	.35	.....	.30	3.53	2.54
Lime	6.55	.72	.25	1.88	3.67
Magnesia,	31	.....	.15	.15	.12
Potash	.02	.07	.17	.04	.27
Soda	.30	.....	.17	.14	.03
Sulphuric acid	.70	.17	.10	.34	.82
Phosphoric acid	.17	1.15	.27	.26	1.97
Carbonic acid, coal, etc	4.29	.....	.20	.20	1.45
Total ash	13.06		3.81	42.07	34.61

In the samples marked 278 and 280, the mineral matter probably consists for the most part of true ash—i. e., matter that once formed a part of the growing moss or other plants; although the large amount of lime in 278 may have come from the shells of minute organisms often found in shallow water. The large excess of mineral matter in the other samples must have proceeded from sand washed in from higher ground and is naturally poor in plant food.

ORGANIC MATTER AND NITROGEN IN MUCK.

From the above table and that on page 73 it is evident that whatever value mucks have as fertilizers is not due to the minute amounts of phosphoric acid and potash which they carry but to the organic matter and its accompanying nitrogen.

Mucks vary greatly in the organic matter which they contain. Occasionally a peaty muck will have as high as 95 pounds of organic matter for each 100 pounds of dry matter, while others will have little more than half that amount. Since the value of the muck as an absorbent depends upon its organic matter, it follows that for litter a peaty muck is better than one that is clayey or sandy.

The nitrogen in mucks is for the most part in inert compounds and is not immediately available for plant food. The quantity of nitrogen in mucks also varies greatly. With one exception the mucks examined at the Station carried more than 1 pound of nitrogen for each 100 pounds of water-free muck. Ten samples had about 2 pounds in 100 and 3 samples had more than 2½ pounds of nitrogen for each 100 pounds of dry matter. It is not a matter of indifference whether the muck is high or low in nitrogen content. While by far the larger part of the nitrogen in these materials is in a form that is insoluble in water and is, considered as a plant food, comparatively inert, it is a matter of common experience that this nitrogen may be made to contribute to the support of crops, and that it has therefore a considerable money value.

When muck is exposed to the action of the air, as when mixed with ordinary cultivated soil, its nitrogen slowly undergoes change and is gradually rendered available to the growing plant. Through the action of bacteria proper to soils the nitrogenous constituents in the humus are changed to ammonia. The most favorable conditions for this bacterial action are moisture, air and warmth and the absence of acidity. Hence the process of conversion of unavailable nitrogen compounds to available forms may be hastened by the addition of lime or ashes to a muck and by composting. The use of muck as a stable absorbent adds greatly to its store of nitrogen because of the nitrogen of the urine thus taken up, and the germs always present in manures accelerate the conversion of the inert nitrogen into available forms.

In the preparation of muck for manure as well as in consideration of preserving farm yard manure the question of composting naturally presents itself. While the ability to procure commercial fertilizers readily has caused composts to fall some-

what into disrepute,—and while in certain localities, near cities, it may be more profitable to expend labor in hauling stable manure than in building compost heaps—it is true of a State of small proprietors, for whose labor there is at times no profitable outgo, that "the composting of muck and peat with stable and barnyard manures is surely destined to become one of the most important items in farm management."

Some mucks ferment of themselves when thrown into heaps and such kinds serve well as manures without weathering, fermentation or any kind of preparation. But the kinds most common in Maine are well nigh useless as manures unless they have been rotted or fermented. In view of these differences it is not strange that farmers frequently deem mere exposure of muck to the air to be a sufficient preparation of this material. While this is the case with some mucks, the safest and surest way of obtaining good results with muck is to ferment artificially in the compost heap.

Experience teaches that in many situations, a large proportion of the useful ingredients of dung and urine can be saved by composting with muck. It is equally certain through such composting the unavailable plant food of the muck is made available. The ferments are present in such amounts in farm manures that left to themselves they suffer by the fermentation, and most mucks are so deficient in ferments that by themselves the fermentation necessary to render their inert organic matter available will not take place.

In the preparation of muck composts, dung or fish are the materials commonly used to excite fermentation. Most farmers prefer to make compost in heaps. A common plan is to lay down a bed of muck six or eight feet wide and a foot or so thick and cover it with a layer of dung of somewhat less thickness, followed by another layer of muck and so on. Different farmers use very different proportions of muck. The ordinary practice seems to vary from 1 to 5 parts of muck to 1 part of dung. Rich dung from stall-fed cattle will ferment more muck than that from animals less highly fed. The practical rule is to use no more muck than can be thoroughly fermented by the manure. In the case of sour muck the addition of small amounts of lime or wood ashes will correct the acidity and hasten fermentation.

Nitrogenous manures cost more than others for the simple reason that concentrated nitrogenous compounds capable of supplying this element to plants are neither abundant nor readily prepared. "New sources of phosphate of lime have continually been discovered, so that the price of this article has not risen from year to year, in spite of the greatly extended use of it. But the assimilable nitrogen compounds are more costly than either phosphates or potash salts, and there is no immediate probability that their price will be much reduced. Hence the importance of recognizing clearly the value of the peat (muck) and the humus which are found already in the fields." *

Seaweeds.

Seaweeds have long been used as manures in this country and in England. Here in New England there is abundant evidence of the great value of sea manure. According to Storer, with the exception of the intervale farms of the Connecticut river, the farms that depend upon manures derived from great cities, and a few localities in which the fertility is based upon fish manure, "the only really fertile tracts in New England are to be found back of the sea beaches upon which an abundant supply of seaweeds is thrown up by storms."

Under the name of seaweed are included a large number of plants which grow in the water on the coast and are found collected on the shelving beaches or in inlets, or adhering to the rocks covered by tide water. From their habit of growth, those which grow upon the rocks between low and high water mark are called rockweed. Others which grow in deeper water from low water mark out to a depth of four or five fathoms and are washed in by the tides are called driftweed or kelp. These materials are valuable agricultural resources to farmers located near tide water, but it is doubtful if the farmers along the coast of Maine fully appreciate their value and utilize them to the extent they should. They are used extensively on the coast of France, Germany, Great Britain, Ireland and southern New England and many fine farms owe their fertility almost wholly to these materials.

*Storer, Agriculture, Vol. II, p. 82.

SEAWEED AS CATTLE FOOD.

While their chief value is as a manure, some varieties of seaweeds are used as food and on some islands near the coast, sheep subsist largely upon them during the winter months.

Mr. H. A. Long of Roque Bluff has for many years been a successful grower of sheep on one of the islands of the Maine coast. During the present winter, agents for the Maine State Society for the Protection of Animals investigated the conditions under which the island sheep are kept. Three years ago Mr. Long sent samples of the kinds of rock weeds eaten by the sheep to the Station for analysis. Because of this and the investigation of the society above named, he recently wrote as follows:

"Are the elements found in the seaweed capable of sustaining life without any other food? We know that our sheep eat it in the winter and practically live on it for six or seven months in the year, and if it will keep them fat and strong, why is it that we must house our sheep and feed them hay and grain as we are told the law requires us to do? My cows will go to the shore nearly every day and eat some of the rockweed from the rocks, and I have never seen any hurt to them, or odor in milk. If possible I wish to have made plain to me the value of a pound of seaweed or rockweed, compared with a pound of good hay fed to a sheep or cow."

As the same question is of importance and interest to many in the state, the chief points given in the answer to Mr. Long are here presented:

The sample sent to the Station by Mr. Long was a mixture of several species of rockweed. They were separated into two lots and analyzed as two samples. The sample called rockweed consisted chiefly of two species of flat-stemmed rockweed, *Fucus vesiculosis* and *Fucus evanescens*. The other sample was sea lettuce. In the following table there is given the analyses of these samples, and for the purpose of comparison, there is also given the average analysis of a few common cattle and sheep fodders.

POUNDS OF WATER AND NUTRIENTS IN 100 POUNDS OF SEA WEEDS AS COLLECTED COMPARED WITH THE WATER AND NUTRIENTS IN 100 POUNDS OF COMMON CATTLE FODDERS.

	Water.	Protein.	Fat.	Fiber.	Nitrogen-free extract.	Ash.
Rockweed (Fucus)	73.9	2.8	.4	3.5	13.1	6.3
Sea lettuce (ulva)	78.6	2.7	.2	2.2	5.7	10.6
Corn fodder (green)	79.3	1.8	.5	5.0	12.2	1.2
Corn silage	79.1	1.7	.8	6.0	11.1	1.4
Timothy grass	61.6	3.1	1.2	20.2	11.8	2.1
Timothy hay	13.2	5.9	2.5	29.0	45.0	4.4
Rye fodder (green)	76.6	2.6	.6	11.6	6.8	1.8
Red clover (green)	70.8	4.4	1.1	8.1	13.5	2.1

It will be seen from the table that in composition these seaweeds compare very well as a food with either corn fodder, corn silage, or rye fodder. While there have been no experiments upon the digestibility of these materials, because of the small amount of woody matter (fiber) in the seaweeds, it is fair to assume that they would be more readily and completely digested than the ordinary cereal green fodders.

SEAWEED AS MANURE.

The Station has analyzed the two specimens above described with reference to the manurial value with the following results:

POUNDS OF WATER, ASH, NITROGEN, PHOSPHORIC ACID, AND POTASH IN 100 POUNDS OF SEAWEED.

	Water.	Ash.	Nitrogen.	Phosphoric acid.	Potash.
Rockweed (*Fucus*)	73.9	6.3	.44	.12	.40
Sea Lettuce (*Ulva*)	78.6	10.6	.43	.10	.40

The Rhode Island Experiment Station made quite a thorough study of the seaweeds of that state, and published the results in bulletin 21 of that Station, which is by far the best treatise on seaweeds and their use yet issued. The figures in the following table are derived from that bulletin. For the sake of comparison

the results of the analysis are all calculated to a water content of 80 per cent.

POUNDS OF NITROGEN, PHOSPHORIC ACID AND POTASH CONTAINED IN 100 POUNDS OF DIFFERENT SEA WEEDS CONTAINING 80 PER CENT WATER AND COLLECTED AT DIFFERENT SEASONS OF THE YEAR.

Kind of sea weed.	Time of year.	Nitrogen.	Phosphoric acid.	Potash.	Lime.
Ribbon weed, kelp or tangle.....	Winter	.38	.09	.57	.31
	Summer	.19	.07	.16	.65
Broad ribbon weed, broad leafed kelp, Devil's apron	Winter	.45	.12	.78	.57
	Summer	.27	.05	.13	.52
Round stalked rock weed..	Winter	.27	.07	.57	.41
	Summer	.13	.06	.55	.45
Flat stalked rock weed.....	Winter	.40	.11	.48	.37
	Summer	.16	.08	.62	.37
Eel grass, grass wrack.....	January	.34	.03	.13	.64
	March	.56	.09	.46	.49
	Sept.	.22	.08	.42	.48

Both species of ribbon weed or kelp are common on the rocks of our coast at and below low water mark, and the round and flat-stalked rockweeds constitute at least three-fourths of the covering of the rocks and stones between tide marks. As seen from the table the plants gathered in the winter season are richer in fertilizer elements that those gathered in the summer. It would, therefore, seem advisable to collect seaweeds during the winter months and if not convenient to apply them at once to the fields, they could be stored in large heaps until spring.

On account of the large water content and consequent weight of seaweeds, transportation far inland is not profitable. A part of the water can be removed by spreading out thinly on the shore and allowing exposure to a hot sun for a few days, but it is a question whether this practice is economical on account of the increased labor involved, and if the material is leached by rains after it has become partially dried a part of the fertilizing element is lost.

In addition to the seaweeds proper which belong to the group of marine algae, the table includes the results of analyses of eel grass. Eel grass is not a true seaweed, but belongs to the pondweed family, a group of (mostly fresh water) aquatic plants. The seaweeds proper rapidly decompose so that their fertilizing constituents become speedily available, and as they have no power of absorbing liquids, there is no advantage in composting them, and they are best applied directly in the green state. This is not true of eel gress, which more nearly resembles straw. While chemical analysis shows it to have nearly as much nitrogen, phosphoric acid and potash as the seaweeds, it is only with difficulty that they can be made available. Storer says, "It will hardly rot anywhere, either in the ground, in the hog-sty, or in the manure or compost heap."

Seaweeds produce their chief effect the first season. This adds to rather than detracts from their value as a fertilizer, since when they can be obtained at all, they can usually be had one year as well as another, and can be applied annually.

The analyses show that seaweeds are not evenly balanced manures. They contain relatively considerable amounts of nitrogen and potash and but little phosphoric acid. Consequently land dressed for a long time with seaweed alone becomes exhausted in phosphoric acid unless a large excess of manure is added which would be wasteful of the nitrogen and potash. Excellent results have been obtained by using phosphates with these manures. Dissolved bone or acid South Carolina rock may be used, 300 to 500 pounds to the acre, with 20 to 30 tons of the fresh seaweed.

With most crops the best results are obtained by applying the fresh material in the spring and either plowing or harrowing it into the soil, but potatoes and some root crops, like the sugar beet, are said to be injured in quality by spring applications. This is probably due to the large amounts of chlorides of magnesia, sodium, etc., they contain, as it is well known that these substances have the effect of depressing the amount of starch in tubers and thereby impairing the quality. Farmers who make use of this material largely for a potato manure overcome this difficulty to a large extent by applying it to the fields in the fall before planting in the spring. In this way potatoes of much better quality, it is claimed, are grown than by applying the seaweeds at the time of planting.

In some localities seaweed is applied as a top dressing to mowing fields, but if applied fresh in the summer season care must be taken not to apply too thickly, as there is danger of killing out the grass, especially on new fields. Some farmers prefer composting for this purpose with stable manure in order to fine the material so that it will spread more evenly over the field. It is probable that the addition of acid South Carolina rock to the compost would greatly increase its value and aid in holding the ammonia. If the fermentation is carried very far, land plaster or muck should be spread over the heap to prevent ammonia from escaping.

Valued on the basis of commercial fertilizers, seaweeds are worth about $1.50 to $2.00 per ton, as gathered, for the plant food they contain. The humus resulting from the use of seaweeds is of additional value to old fields that have been long cultivated. In southern New England the round and flat-stemmed rockweeds are highly prized by farmers for raising corn, and they frequently pay 5 cents per bushel for it as it is cut from the rocks.

Seaweeds have in common with commercial fertilizers the advantage of freedom from weeds, the spores of fungi and the eggs of insects. Practical farmers in Rhode Island say almost unanimously, that potatoes grown on seaweed are smoother and freer from scab than those grown on stable manure.

BONE AS MANURE.

While the Station has in the sixteen years of its existence analyzed numerous samples of bone, its investigations have not added greatly to the knowledge of the value of bones as fertilizer. The Station is, however, in frequent receipt of inquiries relative to the value of bone meal as a manure, and because of these inquiries the following is written.

Bones owe their fertilizing value to the nitrogen and the phosphoric acid which they contain. If a bone is soaked for a long time in dilute muriatic acid, the mineral portion is dissolved and a tough pliable mass of the same shape of the original bone is left. This is the organic matter of the bone, composed chiefly of ossein, a nitrogenous material which by long boiling is changed into glue or gelatine. This organic matter makes up from one quarter to one third of the weight of the bone. If a bone is thoroughly burned in fire the organic matter is destroyed and there is left the bone ash. Bone ash is composed chiefly of phosphate of lime, together with a little carbonate of lime and phosphate of magnesia. Raw bone has, in addition to the mineral matter and the ossein, more or less of fats and oils and some water.

When bone or bone ash is treated with strong sulphuric acid, part of the lime is taken away from the bone phosphate of lime and new compounds are found. One of these new compounds is a phosphate of lime containing only one-third as much lime as did the original bone phosphate. The rest of the lime unites with the acid and makes gypsum or land plaster. In practice, if sufficient acid were used to change all the bone phosphate into acid phosphate, the resulting mass would be too pasty and unmanageable for making fertilizers. When less acid is added, part of the bone phosphate is changed into the acid phosphate, and part into still another compound which has two-thirds as much lime as the original bone phosphate. The acid phosphate

is soluble in water and makes the water soluble phosphoric acid of commercial fertilizers. While the other phosphate is not soluble in water, it is readily available to plants. This is the so-called "reverted" phosphoric acid. The water soluble and the reverted together make up the "available" phosphoric acid of commercial fertilizers. The original prosphate of lime becomes very slowly available as a plant food, while the acidulated phosphate is speedily and completely available. Most of the acidulated phosphate used in the manufacture of fertilizers is not obtained directly from bone, but from bone ash and bone black or from phosphatic rocks, which occur in South Carolina, Florida and other southern states. The acidulated phosphate from rocks is called "dissolved rock" while that from bone ash is called "dissolved bone black." While dissolved bone black commands a higher price than dissolved rock, there is no evidence that the acid phosphate prepared from bone ash is superior as a fertilizer to the acid phosphate from "rock." Bone ash which has not been acted upon by sulphuric acid has comparatively little value as a fertilizer.

BONE MEAL.

Bone meal differs materially from bone ash, because of the ossein (nitrogenous material) which it contains. When bone meal is buried in moist earth the flesh-like ossein putrifies and its nitrogen becomes available to the growing plant. In its decay the ossein helps somewhat to dissolve the bone phosphate of lime and renders it available. The rapidity of the decay of bone is largely dependent upon its fineness. The Connecticut Experiment Station has adopted an arbitrary scale upon which is based the trade valuations of ground bone. Meal that passes through a sieve of one-fifteenth inch mesh is called "fine" and that which will not so pass is termed "coarse." They value the nitrogen in fine bone and tankage at fourteen cents a pound and in coarse at ten cents. They rate phosphoric acid in "fine" bone and tankage at four cents a pound and in coarse at two cents.

Bone meal has been used for many years in England and Germany where its effects have been carefully studied. These investigations show that bone meal does its best "upon soils that are neither too light and dry nor too close and wet," and that it

is of little value on any soil unless the land is well drained and of open texture. Both air and moisture are essential to the fermenting of bone. According to Storer, "bone meal would doubtless answer a good purpose on land newly broken up, and rich in decomposing organic matters, provided the land was neither too stiff nor too dry. So, too, when other conditions are favorable, bone meal will be likely to do better on land full of refuse from a previous crop than on land that has been closely cropped. In New England, it was recognized long ago, by practical men, that bone meal should not be applied to dry soils. It is esteemed in this region, however, for light soils that are fairly moist."

STEAMED BONE.

For the purpose of feeding, raw bones are undoubtedly superior to steamed because of their higher content of ossein. Recent experiments seem to show that in temperate climates lightly steamed bone, even though it may contain two or three per cent less of nitrogen than raw bone, is of greater fertilizing value than raw bone meal. When bones are placed in a closed boiler and are submitted to steam pressure, the bone becomes not only so friable that it can be readily and cheaply ground, but the chemical character of the ossein left in it appears to be changed. Meal thus made decomposes readily in the earth and according to recent experiments in Germany acts as a quicker and more powerful manure than meal from raw bones. In the manufacture of glue, bone is sometimes treated for a long time with steam at high pressure and thus loses the larger part of its ossein. This bone may carry less than one per cent of nitrogen and approaches bone ash in composition and fertilizing value. The lightly steamed bone offered in the market is probably a better fertilizer for most Maine crops and soils than raw bone meal of equal fineness.

Bone meal is by many highly regarded because it is a slow acting fertilizer, and a single application will last for several years. In present practice slow acting fertilizers are not held in as much repute as formerly. The teaching of Voelcker on this point is coming to be more and more followed. "Greater permancy is no recommendation whatever, for the primary use of all manures is to enable us to grow not scanty but heavy

crops; not to deposit on the land fertilizers which may last for three or four years, but by prompt, efficacious action to render a quickly remunerative return from a moderate outlay." The chief objection to the use of bone meal is, indeed, the slowness with which it becomes available.

THE COMPOSITION OF BONE.

Raw bone usually carries nearly six per cent of nitrogen and a little less than twenty per cent of phosphoric acid. The Maine analyses of locally ground bone meals have been found to vary within not very wide limits. The nitrogen in these meals usually runs from about 3.75 per cent to 4.25 per cent and the phosphoric acid from about twenty-one to twenty-three per cent. The imported bone meals sold by manufacturers of commercial fertilizers will frequently run lower than this, but their composition can be ascertained from the guarantees which the manufacturers place upon the packages. The average bone meals as turned out in the Maine mills can be expected to carry about four per cent of nitrogen and about twenty-two per cent of phosphoric acid.

BONE MEAL AND WOOD ASHES.

As shown from the above composition, bone meal is not a complete fertilizer in that it contains no potash. The practice which is quite common in Maine of mixing bone meal with wood ashes is a good one, not only because the wood ashes supply the lack of the bone in potash, but help to render the nitrogen and phosphoric acid more quickly available. Just what changes take place when bone and ashes are mixed together, and kept moist, are not as clearly known as is the action of sulphuric acid upon bone phosphate. Probably the potash of the ashes tends to saponify the fat and bring more or less of the other organic matters into solution. If the fermentation goes on in a heap, precautions should be taken to prevent loss of nitrogen. The action of the ashes upon the organic part of the bones causes the mineral part of the bone to disintegrate to a greater or less extent. There is no evidence, however, that the phosphate of lime in the bone undergoes any chemical change because of the ashes, or that it is any more available to the plants, only so far

as it may have been made finer. This disintegration or the working down of the bone is undoubtedly important in rendering the mineral matters of the bone more available. A mixture of equal weights of ground, lightly steamed bone and good hard wood ashes would carry about two per cent nitrogen, ten per cent phosphoric acid, and three per cent of potash.